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BIOLOGY AND IMMATURE STAGES OF *NOSTIMA APPROXIMATA* (DIPTERA: EPHYDRIDAE), A GRAZER OF THE BLUE-GREEN ALGAL GENUS *OSCILLATORIA*[1]

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Abstract.—Information is presented on the life cycle and larval feeding habits of *Nostima approximata* Sturtevant and Wheeler, a relatively rare species of the ephydrid subfamily Notiphilinae and tribe Philygrini. The larvae are highly specialized trophically and are restricted to feeding on the algal genus *Oscillatoria* and certain other related genera of blue-green algae. In northeastern Ohio, the life cycle can be completed in ca. 25 days, and there are at least five generations a year.

The egg, mature larva, and puparium are described and illustrated. A key is given that separates the eggs, mature larvae, and puparia of *N. approximata* from those of *Lytogaster excavata* (Sturtevant and Wheeler) and *Pelina truncatula* Loew, two other ephydrid species whose larvae are known to feed on soil-inhabiting blue-green algae.

The life history of this species is contrasted and compared with those other species of Ephydridae having larvae that feed on blue-green algae. The larval feeding habits are also compared with those of other species of Notiphilinae. It is suggested that the genus *Nostima* and tribe Philygrini would be better placed in the subfamily Parydrinae rather than in the Notiphilinae.

Containing more than 1200 species, the Ephydridae constitute one of the largest families within the acalyptrate Diptera (Rohdendorf, 1974). Over 400 species are recorded from America north of Mexico (Deonier, 1979), and equally rich faunas occur in the other major biogeographic regions. The family obviously has undergone considerable adaptive radiation and has been referred to as a "family of flies in the full flower of its evolution" (Oldroyd, 1964). The larval feeding habits are remarkably diverse, although a majority of the species probably are microphagous on autotrophic and heterotrophic microorganisms. Larvae of many species are known to utilize algae, bacteria, and yeasts. However, other larvae are scavengers on decaying plant and animal remains; are phytophagous in the leaves and stems of higher plants; or are predators of spider eggs, frog eggs, and midge larvae. Perhaps the most interesting trophic story involves the use of algae as a larval food. Species of *Cirrula, Dimecoenia, Ephydra,* and *Setacera* occur in floating algal mats (Aldrich, 1912; Oliveira, 1954, 1958; Wirth, 1971; Simpson, 1979;

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Mathis and Simpson, 1981; Foote, 1982), while those of *Discocerina, Parydra, Paracoenia,* and *Scatella* are frequently encountered in algae-laden substrates of shoreline habitats (Brock et al., 1969; Foote and Eastin, 1974; Deonier and Regensburg, 1978; Zack and Foote, 1978; Thier and Foote, 1980). A broad spectrum of algal taxa is consumed, and evidence is accumulating that certain groups of phycophagous ephydrids are specialized for particular algal taxa. One such specialization involves an array of species that is adapted for using blue-green algae, a group that is generally considered to be quite recalcitrant to grazing by invertebrate animals (Arnold, 1971).

This is the fifth in a series of papers dealing with life histories of species of Ephydridae whose larvae utilize blue-green algae. The first publication (Foote, 1977) was a general discussion of the use of blue-greens by 12 species of the family; the second (Foote, 1981a) was concerned with *Lytogaster excavata* (Sturtevant and Wheeler), a grazer of soil-inhabiting species of *Cylindrospermum,* the third contribution (Foote, 1981b) elucidated the life history of *Pelina truncatula* Loew, another consumer of *Cylindrospermum*; and the fourth paper dealt with *Setacera atrovirens* (Loew), an inhabitant of floating algal mats (Foote, 1982). The present paper elucidates the life cycle, discusses larval food preferences, and describes the immature stages of *Nostima approximata* Sturtevant and Wheeler, a grazer of the blue-green algal genus *Oscillatoria.* In addition, the biology of this species is contrasted and compared with those of other species known to utilize blue-green algae.

The genus *Nostima* is usually placed in the subfamily Notiphilinae and tribe Philygrini along with the genera *Philygria* and *Lemnaphila* (Wirth, 1965). However, Dahl (1959) included it in the subfamily Hydrininae along with the genera *Hyadina* (including *Axysta* and *Lytogaster*) and *Hydrina* (= *Philyria*), stating that *Nostima* was "closely allied to *Hydrina.*" Dahl (1959) referred to a holarctic species, *N. picta* Fallén, as "our most beautiful ephydrid." Both he and Sturtevant and Wheeler (1954) commented upon the rarity of the species of *Nostima* in museum collections.

The world fauna of *Nostima* consists of ca. 28 species, with a preponderance of the species occurring in the Neotropical Region. The Americas south of the United States have 15 described species (Wirth, 1968) and probably contain several additional undescribed species. Rather surprisingly, only three species are recorded from the Afrotropical Region (Cogan, 1980), and none is known from the Oriental Region. Two species have been recorded from the Palearctic Region (Becker, 1926), and eight species are known to occur in North America north of Mexico (Wirth, 1965). Only one of the Nearctic species, *N. picta,* is also recorded from Europe, but four species have ranges that extend into the Neotropics. Only *N. approximata, N. picta, N. quinquenotata* Cresson, and *N. scutellaris* Cresson have been recorded from the northern United States, and apparently only *N. picta* and *N. scutellaris* are known to occur in Canada. In contrast, five of the eight Nearctic species occur in Florida.

MATERIALS AND METHODS

All field and laboratory work was carried out in northeastern Ohio near the city of Kent in Portage County. Laboratory rearings providing life cycle data were carried out in an environmental chamber programmed to give a photoperiod of

15L:9D and a temperature of 22°C (± 1°C). Monocultures used in the larval feeding tests were mostly obtained from The University of Texas Culture Collection of Algae (Starr, 1978). Monocultures of algae utilized in the feeding tests, along with their UTEX strain numbers, are listed below. Species lacking UTEX numbers were obtained from nature or the phycology laboratory at Kent State University. Each algal monculture was established on a nutrient agar substrate in sterile petri plates. Feeding tests were performed as outlined in Zack and Foote (1978).

Cyanophyceae

Anabaena flos-aquae (1444)
Anabaena variabilis (B377)
Cylindrospermum sp. (LB942)
Gloeocapsa alpicola (B589)
Lyngbya spiralis (B1831)
Nostoc commune (584)
Oscillatoria limosa
Oscillatoria tenuis (B428)
Phormidium sp. (1540)
Scytonema sp.
Symploca muscorum (B617)
Synechococcus leopoliensis (625)

Chlorophyceae

Chlamydomonas acidophila

Chlorophyceae (*cont.*)

Chlamydomonas eugametos (9)
Chlorella vulgaris (29)
Cosmarium botrytis (175)
Scenedesmus quadricauda (76)

Euglenophyceae

Euglena gracilis var. *bacillaris* (L884)

Bacillariophyceae

Navicula pelliculosa (668)

Chrysophyceae

Botrydiopsis alpina (295)
Botrydium becherianum (158)

Life History

Adults of *Nostima* are rarely collected but are usually taken in wetland habitats supporting stands of grasses, rushes, and sedges. Deonier (1965) apparently did not encounter *N. approximata* in Iowa but recorded *N. scutellaris* as rare in the sedge-meadow habitat. Scheiring and Foote (1973) similarly reported that *N. scutellaris* was rare in sedge meadows but failed to collect *N. approximata*. Sturtevant and Wheeler (1954) collected specimens of *N. scutellaris* at lights. Dahl (1959) commented that *N. picta* in Scandinavia was a "distinctly hydrophilous species" and occurred in maritime as well as freshwater habitats. I have never encountered adults of *N. approximata* in nature, but larvae were found in algae-laden soil samples taken from the partly shaded borders of a sedge marsh and from a drying drainage ditch that supported a dense stand of grasses and sedges. In all larval substrate samples, blue-green algae, particularly species of *Oscillatoria*, were abundant. Other ephydrid species repeatedly taken in habitats supporting *Nostima* populations were *Hydrellia* spp., *Hyadina* spp., and *Lytogaster excavata*.

Very little information is available concerning seasonal distribution of *N. approximata*, as no adults were collected. Larvae were taken in nature on August 20, September 13, October 10, and October 22. These all formed puparia in the laboratory from which adults emerged several days later. This suggests that adults can occur at least during the late summer and fall in northern Ohio. Judging from the overwintering habits of other northern Ephydridae, *N. approximata* survives the cold season as adults.

Adult longevity in the laboratory rearings varied between 20 and 36 days and averaged 26 days ($n = 8$). Males usually died several days prior to the females, and the longest longevity was obtained for a female that lived for 36 days before succumbing to lethal temperatures when the environmental chamber overheated. Adults fed readily on monocultures of *Oscillatoria limosa* and seemingly required no other food substrates. In contrast, adults placed in cultures of such algal genera as *Anabaena, Chlorella,* and *Navicula* died within five days. Apparently there is no trophic separation in the adult and larval stages of *N. approximata,* as both stages consumed the blue-green algal genus *Oscillatoria.*

The premating period from emergence of both sexes to their first copulation in the laboratory rearings varied from two to three days and averaged 2.5 days ($n = 5$). No overt courtship displays were observed, and males seemingly attempted to mate randomly with any other adult *Nostima* in the rearing dishes. After and between copulations, males usually remained in contact with females in a "riding" position. Riding was observed to last as long as 30 minutes in one pair, although it usually lasted less than 15 minutes. Occasionally, males were seen "riding" other males, although this behavior rarely lasted more than a few minutes. In one case, a riding male repeatedly attempted to copulate with his subordinate male. Parker (1970) reported that similar riding behavior in an anthomyiid fly, *Scatophaga stercoraria* L., served to prevent insemination of the female by later arriving males, thus ensuring that the riding male's sperm would actually fertilize the female's eggs.

The preoviposition period from emergence of a female to her first deposition of eggs, with males constantly available, varied from three to four days ($n = 5$). Females scattered eggs over a suitable algal substrate; rarely were eggs clustered. In the petri dishes females repeatedly oviposited onto growths of *Oscillatoria limosa, Anabaena variabilis,* and *Symploca muscorum,* but failed to oviposit in cultures of *Navicula pelliculosa* and *Botrydiopsis alpina* during the ca. five days they survived in dishes containing those algae. The vast majority of eggs were not buried in the substrate but were placed directly on the algal surface. Very few were scattered over areas of the agar surface lacking an algal growth. It is apparent that females are rather restrictive in their use of potential oviposition sites and in nature probably expend considerable energy in seeking out colonies of *Oscillatoria.* It is possible that only *O. limosa* serves as the oviposition site in northeastern Ohio, as no eggs or larvae of *Nostima* were ever found in such soil algae as species of *Anabaena, Cylindrospermum,* and *Nostoc* even though these algal genera frequently were abundant in the *Nostima* habitats. Even more surprising is the fact that no immature stages of *Nostima* were ever found on the other species of *Oscillatoria* that occurred on exposed muddy and sandy shores near Kent. *Oscillatoria limosa* is "common in stagnant water of ditches and small ponds" (Prescott, 1962) and undoubtedly becomes stranded on moist, vegetation-shaded substrates as water levels recede within drainage channels. The possible restriction of oviposition to this species of alga may go far in explaining the apparent rarity of *N. approximata.* It is probable that the species becomes relatively common only when the host alga becomes exposed and available for oviposition.

The fecundity of females retained in petri dishes containing monocultures of *O. limosa* was quite high, ranging from a low of 216 to a high of 581 eggs ($n = 5$). The female that produced over 500 eggs was killed by a malfunction of the

Table 1. Results of larval feeding tests for *Nostima approximata* using different algal monocultures.

Alga		Percent Reaching Different Life Stages			
	n	2L	3L	P	A
Cyanophyceae					
Anabaena flos-aquae	10	0	0	0	0
Anabaena variabilis	10	80	80	40	20
Cylindrospermum sp.	20	0	0	40	0
Gloeocapsa alpicola	10	0	0	0	0
Lyngbya spiralis	10	100	0	0	0
Nostoc commune	10	0	0	0	0
Oscillatoria limosa	15	100	100	100	100
Oscillatoria tenuis	25	100	92	80	72
Phormidium sp.	10	0	0	0	0
Scytonema sp.	5	0	0	0	0
Symploca muscorum	20	100	100	95	95
Synechococcus leopoliensis	10	0	0	0	0
Chlorophyceae					
Chlamydomonas eugametos	5	0	0	0	0
Chlorella vulgaris	5	0	0	0	0
Cosmarium botrytis	5	0	0	0	0
Scenedesmus quadricauda	5	0	0	0	0
Chlamydomonas acidophila	5	0	0	0	0
Euglenophyceae					
Euglena gracilis	5	0	0	0	0
Bacillariophyceae					
Navicula pelliculosa	5	0	0	0	0
Chrysophyceae					
Botrydiopsis alpina	5	0	0	0	0
Botrydium becherianum	5	0	0	0	0

environmental chamber. Her ovaries still contained 28 recognizable eggs when she was dissected two days after death, suggesting that her total fecundity could have exceeded 600 eggs. This female laid an average of 16 eggs daily during the 36 days she remained alive, with a daily output varying from 0 to 51. The incubation period ranged from three to five days and averaged 4.2 days ($n = 20$).

Table 1 summarizes the results of laboratory feeding tests utilizing unialgal cultures. Larvae completed development and eventually became adults only on the blue-green algal species *A. variabilis, O. limosa, O. tenuis,* and *S. muscorum.* None of the other algal species tested allowed larvae to reach the third instar, suggesting that *N. approximata* is highly specialized trophically. The *Anabaena* results are puzzling, as no eggs or larvae were ever found on colonies of this genus in nature. This, coupled with the low percentage (20%) of larvae that eventually became adults when fed this alga, implies that *Anabaena* is not utilized by *Nostima* in nature. Larvae were also able to complete development on *S. muscorum,* with 95% of the larvae eventually becoming adults. However, at least in northeastern Ohio, this is a very rare algal species and was never encountered in habitats containing larvae of *Nostima.*

Table 2. Developmental times for *Nostima approximata* on monocultures of blue-green algae.

	Larval Period			Pupal Period			Combined Period		
Alga	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s
Anabaena variabilis	4	11.25	0.96	2	9.00	0.00	2	19.50	0.71
Oscillatoria limosa	15	7.80	1.21	15	8.27	0.59	15	16.07	1.62
Oscillatoria tenuis	20	10.00	1.49	18	8.39	0.50	18	18.28	1.60
Symploca muscorum	20	10.50	1.20	19	8.60	0.48	18	19.10	1.24

As Table 2 illustrates, the four blue-green species that were utilized by the larvae resulted in no significant differences in the duration of the developmental period from hatching to adult emergence, although the larval period was somewhat shorter when *O. limosa* served as the larval food.

As described for *L. excavata* (Foote, 1981a), larvae of *N. approximata* fed on the algal surface and did not burrow into the matrix to any extent. However, larvae became partially concealed once feeding began because small pieces of algal material adhered to the dorsal surface of the body. Feeding movements resembled those of *Pelina truncatula* (Foote, 1981b) in that the larvae moved slowly over the algal surface while pulling algal trichomes into the oral aperture. However, *Nostima* (Fig. 3) lacks the distinctive comblike structures so prominent on the facial mask of *Pelina* and thus may be incapable of ripping apart *Oscillatoria* trichomes, a capability that is well developed in both *P. truncatula* and *L. excavata.* The pharyngeal sclerite lacks pharyngeal ridges (Fig. 13), and it is very doubtful if a filtering mechanism such as that described for other species of microphagous Ephydridae (Foote, 1982) exists in this species. Instead, whole trichomes or fragments of trichomes are ingested and passed back into the proventriculus. In this respect, larvae of *Nostima* resemble those of species of *Lytogaster* and *Pelina* which also have poorly developed pharyngeal ridges. However, *Nostima* may represent the culmination of a trend line that involves the progressive reduction of the ridges, as they are completely absent in larvae of *N. approximata.*

Larvae of *Nostima* commonly fed collectively on patches of *Oscillatoria*, and as many as eight larvae were found feeding within a 4 cm^2 area of the host alga in nature. Larvae showed no antagnostic behavior to each other and frequently fed side by side. When a larva wandered off of an *Oscillatoria* mat, it became more active and carried out more turning movements. This behavior usually resulted in the larva re-discovering the food substrate. Examination of the gut contents of field-collected larvae showed a great preponderance of *Oscillatoria* trichomes, with very few if any cells of other algal genera.

The only other insect larvae found in association with *Nostima* on patches of *Oscillatoria* were those of undetermined species of Chironomidae. The guts of the midge larvae contained numerous *Oscillatoria* trichomes, suggesting that larvae of these two insect taxa could be in competition for a possibly limited resource.

The larval period of *N. approximata* under laboratory conditions when *O. limosa* served as the food substrate varied from seven to ten days and averaged nine days ($n = 8$). Fully mature larvae ceased feeding, voided the gut contents,

Table 3. Life cycle data for *Nostima approximata* in northeastern Ohio. All rearings were maintained at 22°C, with *Oscillatoria limosa* serving as the adult and larval food.

Flight period	unknown
Premating period	2–3 days
Preoviposition period	3–4 days
Incubation period	3–5 days
Larval period	7–10 days
Pupal period	7–10 days
Adult longevity	ca. 25 days
Fecundity	ca. 600 eggs/female

and tended to move to somewhat higher and thus drier areas of the algal mat where pupariation occurred. The pupal period ranged from seven to ten days and averaged 8.3 days ($n = 15$).

The only enemy determined for the immature stages of *N. approximata* was a species of diapriid wasp (Hymenoptera: Diapriidae) that was reared from field-collected puparia.

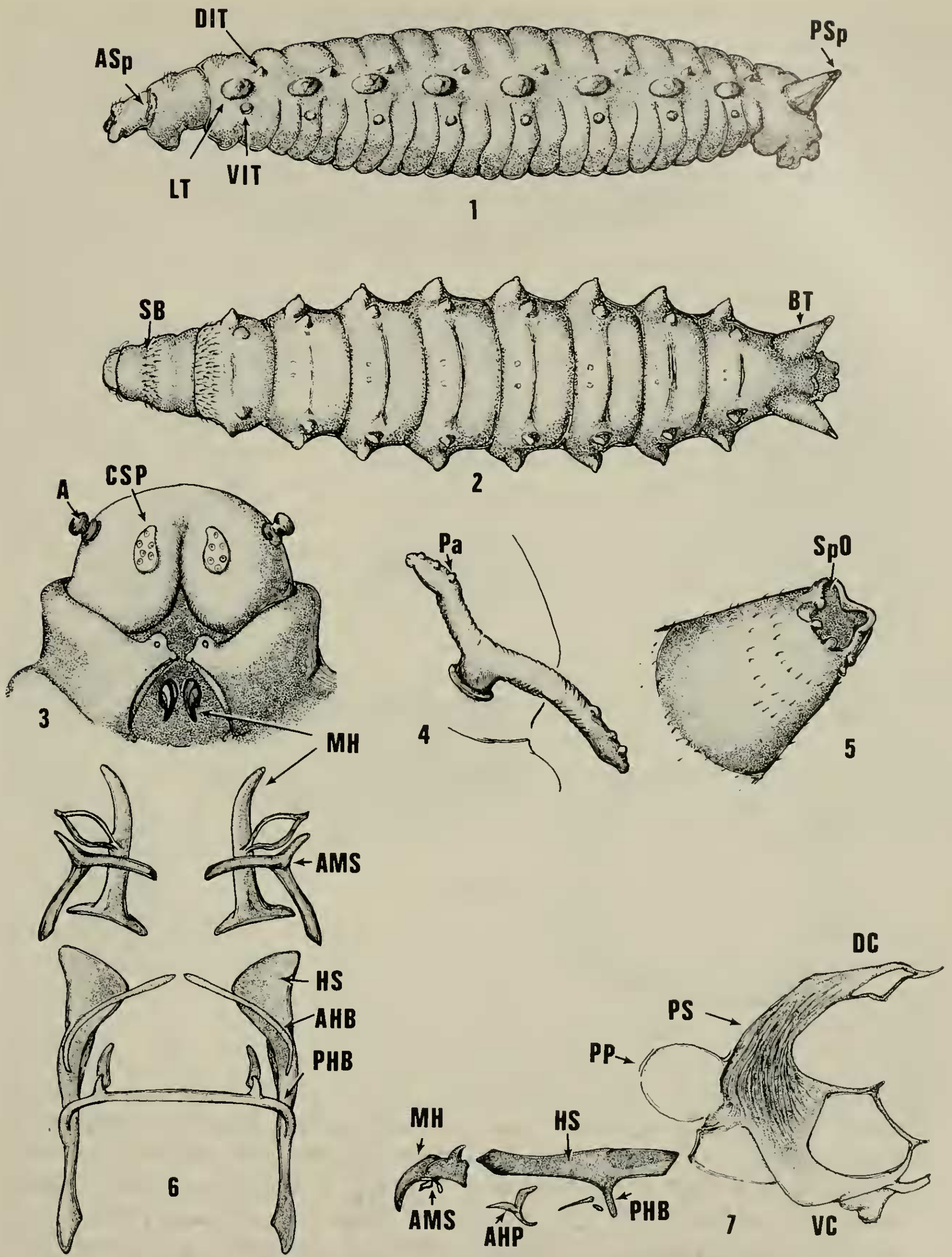
With a preoviposition period of 3–4 days, an incubation period of 3–5 days, and a combined larval-pupal period of 14–20 days, the life cycle can be completed in 20–29 days (Table 3). This suggests that at least five generations could be produced in northern Ohio during a warm season lasting from mid-May to mid-October.

Descriptions of Immature Stages

Egg (Fig. 12).—Length 0.35–0.40 mm, $\bar{x} = 0.38$; width 0.15–0.18 mm, $\bar{x} = 0.17$ ($n = 10$). Ovoid, ends bluntly rounded; micropylar end (Fig. 12a) with small array of encircling tubercles subapically on dorsal side, opposite end distinctly less tuberculate. Chorion white, distinctly reticulate.

Mature third-instar larva (Figs. 1, 2).—Length 1.8–2.2 mm, $\bar{x} = 2.0$; width 0.6–0.8 mm, $\bar{x} = 0.7$ ($n = 5$). Somewhat flattened dorsoventrally. Anterior end tapering, posterior end bearing 2 strongly diverging breathing tubes; margins of body irregular, bearing 3 rows of low tubercles. Integument lacking bristles and hairs except on anterior few segments.

Segment 1 (pseudocephalic) (Fig. 3) frequently invaginated, bearing antennae anterolaterally and circular sensory plates apicoventrally, facial mask area around oral aperture without rows of comblike structures; antenna short and blunt, appearing 2 segmented; circular sensory plates somewhat elongate, with bordering rims complete, each plate with few short peglike structures. Segment 2 (prothoracic) spinulose, particularly on dorsal and lateral surfaces, bearing deeply bifurcate anterior spiracles posterolaterally; each spiracle (Fig. 4) with 2 strongly diverging branches, each branch bearing 3–4 small sessile papillae along outer surface, base of spiracle arising from lightly pigmented ring. Segments 3–11 (Fig. 1) very similar, lateral margins indented and bearing ventrolateral, lateral, and dorsolateral rows of tapering tubercles, lateral tubercles largest; dorsum of each segment (Fig. 9) with 2 circular clear areas along middorsal line, ventral surface (Fig. 10) with poorly defined creeping welt, welt lacking spinules. Segment 12 bearing perianal pad ventrally and breathing tubes apicolaterally; perianal pad



Figs. 1–7. *Nostima approximata,* third-instar larva. 1, Lateral habitus. 2, Dorsal habitus. 3, Facial mask. 4, Anterior spiracle. 5, Breathing tube and posterior spiracle. 6, Ventral view of cephalopharyngeal skeleton. 7, Lateral view of cephalopharyngeal skeleton. Abbreviations: A = antenna; AHB = anterior hypostomal bridge; AHP = anterior hypostomal plate; AMS = accessory mouth sclerite; ASp = anterior spiracle; BT = breathing tube; CSP = circular sensory plate; DIT = dorsolateral tubercle; DC = dorsal cornu; HS = hypostomal sclerite; LT = lateral tubercle; MH = mouthhook; Pa = papilla; PHB = posterior hypostomal bridge; PP = pharyngeal process; PS = pharyngeal sclerite; PSp = posterior spiracle; SB = spinule ban; SpO = spiracular opening; VC = ventral cornu; VIT = ventrolateral tubercle.

(Fig. 11) somewhat bilobed, surrounded by pale rim, lacking postanal spinule pad. Breathing tubes (Fig. 5) elongate, diverging, and tapering, 2–3× as long as width at base; each tube capped apically by spiracular plate, each plate bearing 3–4 poorly defined spiracular openings, hairlike processes around spiracular openings seemingly lacking.

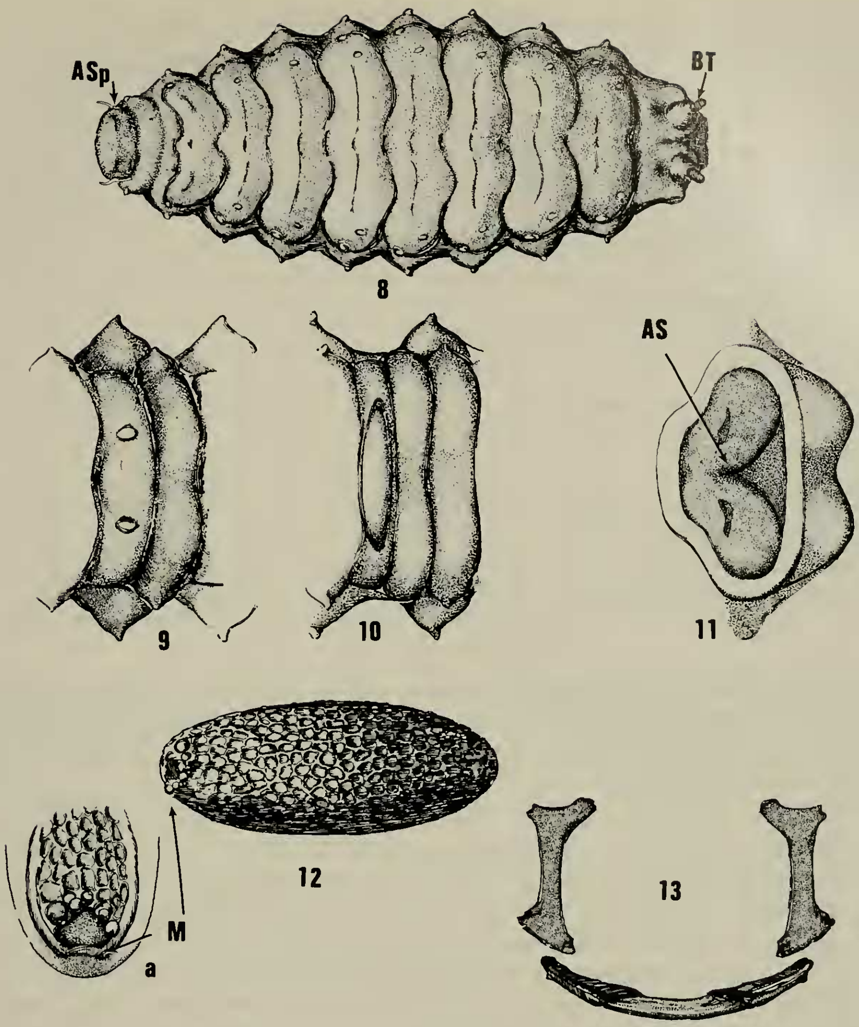
Cephalopharyngeal skeleton (Figs. 6, 7) length 0.38–0.42 mm, $x = 0.40$ ($n = 5$). Mouthhooks (Fig. 6) paired and not connected dorsally; hook part narrow and only slightly curved, lacking accessory teeth; basal part abruptly broadened and lacking window. Accessory mouth sclerite below each mouthhook with 1 short and 2 long branches. Hypostomal sclerite (Fig. 6) composed of 2 lateral rods connected by 2 narrow, arched hypostomal bridges; anterior bridge apparently not completely sclerotized medially; posterior bridge complete, bearing 2 narrow projections on anterior margin; lateral rods distinctly broadened anteriorly; hypostomal sclerite not fused with mouthhooks or pharyngeal sclerite. No apparent epistomal sclerite or parastomal bars. Pharyngeal sclerite mostly deeply pigmented, both dorsal and ventral cornua with large windows apically, dorsal cornua connected anteriorly by poorly defined bridge, pharyngeal processes projecting anteriorly from pharyngeal sclerite large, poorly pigmented and semicircular; floor of pharyngeal sclerite (Fig. 13) lacking pharyngeal ridges.

Puparium (Fig. 8).—Length 1.6–2.0 mm, $\bar{x} = 1.8$; width 0.6–0.8 mm, $\bar{x} = 0.7$ ($n = 10$). Broadest at midlength in dorsal view, gradually tapering to each end, not swollen dorsoventrally at midlength in lateral view, ends of puparium somewhat upturned; anterior end invaginated, bearing bifurcated anterior spiracles apicolaterally; posterior end bearing elongate, diverging breathing tubes apicodorsally; margins of puparium somewhat irregular bearing 3 rows of reduced tubercles along length of puparium. Color uniformly pale brown, without conspicuous blackened scales or spinules; ventral creeping welts very reduced.

DISCUSSION

In contrast to such widely distributed and trophically generalized species of Ephydridae as *Scatella stagnalis* Fallén (Zack and Foote, 1978; Foote, 1979), *N. approximata* must be considered a highly specialized species. It is rare, has a somewhat restricted geographic distribution, probably occurs only in vegetated habitats in which water levels fluctuate, and possibly feeds in nature only on the blue-green algal genus *Oscillatoria.* Thus, its trophic specialization parallels that of species of the hyadinine genera *Lytogaster* and *Pelina* whose larvae apparently are largely restricted to feeding on the algal genus *Cylindrospermum* (Foote, 1981a, 1981b). As Table 4 illustrates, larvae of those two genera seemingly are incapable of utilizing *O. limosa.* Conversely, larvae of *Nostima* cannot develop on *Cylindrospermum.* Thus the hyadinine species and *N. approximata* coexist in the same habitat but are ecologically isolated by utilizing different food resources.

Although little biological information is available for other species of genera of Philygrini, it appears that *N. approximata* is in a unique trophic niche. The only indication of the larval food of a species of *Philygria* is the report of Wheeler (1973) that larvae of *P. debilis* Loew occur in the rotting crowns of alfalfa. The nature of the larval microhabitat suggests that the larvae are ingesting decay products and heterotophic microorganisms rather than algae. Larvae of *Lem-*



Figs. 8–13. *Nostima approximata,* immature stages. 8, Dorsal view of puparium. 9, Dorsal view of segment 9 of third-instar larva. 10, Ventral view of segment 9 of third-instar larva. 11, Perianal pad of third-instar larva. 12, Dorsal view of egg. 12a, Enlargement of micropylar end. 13, Cross section of pharyngeal sclerite. Abbreviations: AS = anal slit; ASp = anterior spiracle; BT = breathing tube; M = micropylar end.

naphila, the only other Nearctic genus of Philygrini, are phytophagous as they are known to mine the floating leaves of duckweed, *Lemna minor* L. (Scotland, 1934, 1940). Generalizing further, no other tribe of the Notiphilinae, the subfamily in which *Nostima* is presently placed, contains species having larval feeding habits similar to those of *N. approximata.* Larvae of *Hydrellia* of the tribe Hydrellini are leaf miners in vascular plants (Deonier, 1971); those of *Typopsilopa* of the Typopsilopini feed on a wide mix of autotrophic and heterotrophic microorganisms but cannot utilize *Oscillatora* (unpublished observations); those of *Notiphila*

Table 4. Comparative utilization of blue-green algae by three species of Ephydridae.

Alga	Percent Reaching Adult Stage		
	N. approximata	*L. excavata*	*P. truncatula*
Order Chroococcales			
Family Chroococcaceae			
Gloeocapsa alpicola	0	0	0
Synechococcus leopoliensis	0	0	0
Order Oscillatoriales			
Family Oscillatoriaceae			
Lyngbya spiralis	0	0	40
Oscillatoria limosa	100	0	0
Oscillatoria tenuis	72	0	30
Phormidium sp.	0	30	0
Order Nostocales			
Family Nostocaceae			
Anabaena flos-aquae	0	0	20
Anabaena variabilis	20	70	100
Cylindrospermum sp.	0	40	100
Nostoc commune	0	0	0

of the Notiphilini engulf anaerobic sediments that are rich in organic detritus (Busacca and Foote, 1978; Deonier et al., 1978); and those of *Dichaeta* (Notiphilini) are generalized consumers of microorganisms in limnic wrack stranded in shoreline habitats (Eastin and Foote, 1971).

The fact that larvae of *N. approximata* utilize blue-green algae suggests that the genus *Nostima,* and probably other genera of the tribe Philygrini, should be placed in the subfamily Parydrinae rather than in the Notiphilinae. The morphology of the mature larva, interestingly, is more similar to that of the hyadinine species than it is to any of the reared species of Notiphilinae. Mathis (personal communication), on the basis of adult morphology, has arrived at a similar conclusion and plans to transfer the Philygrini to the Parydrinae in the forthcoming second volume of the Manual of Nearctic Diptera.

The immature stages of three species of ephydrids utilizing soil-inhabiting blue-green algae can be separated by use of the following key. Characters useful for distinguishing species of *Hyadina* from those of *Lytogaster* have not yet been discovered.

KEY TO IMMATURE STAGES OF *L. excavata, P. truncatula,* AND *N. approximata*

EGGS

1. Ends of egg upturned, chorion striated or reticulated; embryo white . . . 2
– Ends of egg not upturned, chorion papillose; living embryo peach-colored . . . . *P. truncatula* Loew
2. Chorion striated, with longitudinal ridges . . . . *L. excavata* (Sturtevant and Wheeler)
– Chorion reticulated, without longitudinal ridges . . . . *N. approximata* Sturtevant and Wheeler

MATURE LARVAE

1. Dorsum of larva with distinct pattern formed by blackened scales and spinules .... *P. truncatula* Loew
– Dorsum of larvae unpatterned, uniformly colored 2
2. Body length over 3.0 mm; facial mask with several darkened, comblike structures near oral aperture; breathing tubes elongate, at least ⅓ length of body .... *L. excavata* (Sturtevant and Wheeler)
– Body length under 2.5 mm; facial mask (Fig. 3) lacking comblike structures; breathing tubes short, less than ¼ length of body .... *N. approximata* Sturtevant and Wheeler

PUPARIA

1. Dorsum of puparium with dark pattern, as in mature larva .... *P. truncatula* Loew
– Dorsum unpatterned, uniform in color 2
2. Body length over 3.0 mm; breathing tubes elongate, at least ⅓ length of body of puparium .... *L. excavata* (Sturtevant and Wheeler)
– Body length under 2.5 mm; breathing tubes short, less than ¼ length of puparium (Fig. 8) .... *N. approximata* Sturtevant and Wheeler

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